CHAPTER 9

ENGINEERING CASUALTY CONTROL

This chapter provides general information on engineering casualty control, a phase of damage control. If a review of damage control principles and related information is necessary, see *Basic Military Requirements*, NAVEDTRA 10054 (current edition), *Military Requirements for Petty Officer 3 & 2,* NAVEDTRA 10056 (current edition), *Fireman,* NAVEDTRA 10520 (current edition), and *Naval Ships' Technical Manual,* chapter 079. The mission of engineering casualty control is to maintain all engineering services in a state of maximum readiness and reliability. To carry out this mission, it is necessary for all personnel concerned to know what actions are necessary to prevent, minimize, and correct any effects of operational and battle casualties on the machinery and the electrical and piping installations of their ship.

The primary objective of casualty control is to maintain a ship in such a condition that it will function effectively as a fighting unit. This requires effective maintenance of propulsion machinery, electrical systems, interior and exterior communications, fire control, electronic services, ship control, fire main supply, and of such miscellaneous services as heating, air conditioning, and compressed air. Failure of any of these services will affect a ship's ability to fulfill its primary objective, either directly, by reducing its power, or indirectly, by creating conditions which would lower personnel morale and efficiency.

A secondary objective of casualty control is to minimize personnel casualties and secondary damage to vital machinery.

You can find detailed information on casualty control in the *Engineering Casualty Control Manual*, the *Damage Control Book*, the *Ship's Organization Book*, and the *Ship's Repair Party Manual.* Although these publications vary from ship to ship, they explain the organization and the procedures that must be followed when engineering casualties, damage to the ship, or other emergency conditions occur.

FACTORS INFLUENCING CASUALTY CONTROL

The basic factors influencing the effectiveness of engineering casualty control are much broader than the immediate actions taken at the time of the casualty. Engineering casualty control efficiency is obtained through a combination of sound design, careful inspection, thorough plant maintenance (including preventive maintenance), and effective personnel organization and training. CASUALTY PREVENTION IS THE MOST EFFECTIVE FORM OF CASUALTY CONTROL.

DESIGN

Design influences the effectiveness of casualty control in two ways: (1) the elimination of weaknesses which may lead to material failure and (2) the installation of alternate or standby equipment for supplying vital services in the event of a casualty to the primary equipment. Both of these factors are considered in the design of naval ships. Each individual plant aboard ship is equipped with duplicate vital auxiliaries, loop systems, and cross connections. All complete propulsion plants are designed to operate as isolated units (split-plant design).

CASUALTY CONTROL COMMUNICATIONS

Casualty control communications is extremely important to the operation and organization of the ship. Without adequate and proper means of communication between the different units, the whole organization of casualty control will fail in its primary objective.

To ensure that sufficient means of communications are available, several different systems are installed aboard ship. The normal means of communications are the battle telephone circuits (sound powered), interstation 2-way systems (intercoms), ship service telephones, ship's loud speaker (1-MC), and voice tubes. Messengers are also used in some situations when other methods of communications are not available or when written reports are required.

The transmission of correct information regarding a casualty and the speed with which the report is made are essential to be of value in any method of communication.

It is also essential that control of all communication circuits be established by the controlling station. The circuits must never be allowed to get out of control, because of "cross-talk" caused by more than one station operating at the same time and each assuming that it has the priority message. Casualty control communication must be incorporated into casualty control training, since prompt action to notify the control station or engineering control of a casualty must be taken to prevent the development of other casualties which could be more serious than the original casualty.

INSPECTION AND MAINTENANCE

Inspection and maintenance are vital to successful casualty control, since they minimize the occurrence of casualties due to material failures. Continuous and detailed inspections are necessary not only to discover partly damaged parts which may fail at a critical time, but also to eliminate any underlying conditions which may lead to early failure (maladjustment, improper lubrication, corrosion, erosion, and other causes of machinery damage). Particular and continuous attention must be paid to symptoms of malfunctioning, such as unusual noises, vibrations, abnormal temperatures, abnormal pressures, and abnormal operating speeds.

Operating personnel should thoroughly familiarize themselves with the specific temperatures, pressures, and operating speeds required for the normal operation of equipment, in order to detect all departures from normal operation.

When a gage, or other instrument recording the operating conditions of machinery, gives an abnormal reading, the cause must be fully investigated. A spare instrument, or a calibration test, will quickly indicate whether or not the abnormal reading is due to instrument error. Any other cause must be traced to its source.

Because of the safety factor commonly incorporated in pumps and similar equipment, considerable loss of capacity can occur before any external evidence is readily apparent. Changes in the operating speeds (from those normal for the existing load) of pressure-governor-controlled equipment should be viewed with suspicion. Variations from normal pressures, lubricating oil temperatures, and system pressures indicate either inefficient operation or poor condition of machinery.

When a material failure occurs in any unit, a prompt inspection should be made of all similar units to determine if there is danger that other similar failures might occur. Prompt inspection will prevent a series of repeated casualties.

Strict attention must be paid to the proper lubrication of all equipment. Frequent inspections and samplings must be made to ensure that the correct quantity of the proper lubricant is in the unit. Lube oil samples must be taken daily on all operating auxiliaries. Lube oil samples should be allowed to stand long enough for any water to settle. Where auxiliaries have been idle for several hours, particularly overnight, a sufficient sample should be drained from the lowest part of the oil sump to remove all settled water. Replenishment with fresh oil to the normal level should be included in this routine.

The presence of saltwater in the oil can be detected by running a standard chloride test. A sample of sufficient size for test purposes can be obtained by adding distilled water to the oil sample, shaking vigorously, and then allowing the water to settle before draining off the test sample. Because of its corrosive effects, saltwater in the lubricating oil is far more dangerous to a unit than an equal quantity of freshwater. Saltwater in units containing oil-lubricated ball bearings is particularly harmful.

TRAINING

Casualty control training must be a continuous step-by-step procedure and should provide for refresher drills. Any realistic simulation of casualties must be preceded by adequate preparation. You and your work center personnel must learn to understand fully the consequences of any error which may be made in handling real or simulated casualties.

The majority of all engineering plant casualties can be attributed to a lack of knowledge of the correct procedures on the part of the watch station personnel. Often a relatively simple problem, if allowed to compound itself, could lead, ultimately, to the disabling of the ship. The causes of ineffective casualty control and their prevention are listed as follows:

1. Lack of positive control. The Engineering Officer of the Watch (EOOW) must maintain positive control of every situation that arises and must possess thorough knowledge of the correct procedures and systems operation.
2. Lack of effective communications. Communications throughout the engineering plant must be maintained at all times. The repeat back technique for watchstanders is the only means of ensuring that communications are received and understood.
3. Lack of systems knowledge. Watch personnel are frequently shallow in their depth of systems knowledge and approach to casualty control. Watch sections must be familiar with the operation and theory of all vital engineering systems.
4. Lack of casualty control assistance. Off-watch personnel are not called to assist in casualty control follow-up actions with the result that watchstanders are unable to satisfactorily deal with recovering from a casualty. Off-watch personnel must be called to provide requisite expertise and augment assigned watchstanders performing restoration actions.

In the past, the primary emphasis in casualty control training has been placed on speed. However, with the development and implementation of the Engineering Operational Casualty Control (EOCC) portion of the Engineering Operational Sequence System (EOSS), a more methodical and organized approach to casualty control has resulted in increased control, less disabling of a plant, and an increase in the overall safety to the plant and personnel.

To ensure maximum engineering department operational readiness, a ship must be self sufficient in the conduct of propulsion plant casualty control drills. The management required for such drills involves the establishment of the Engineering Casualty Control Evaluation Team (ECCET) and the preliminary administrative support for the training program.

Engineering Casualty Control Evaluation Team (ECCET)

An ECCET should be developed for each underway watch section, and a sufficient number of personnel should be assigned to evaluate each watch station during the drills.

The engineer officer must ensure the development of an accurate, comprehensive drill package adequate to exercise the engineering department in all phases of casualty control procedures. The drill package should contain a complete file of drill scenarios and drill cards for each type of casualty that could reasonably occur to the propulsion plant. The scenarios should contain the drill title, scenario number (if assigned), a general description of the casualty, the method of imposing the drill, the cause (several possible causes should be listed) and estimated time of repair (ETR), cautions to prevent personnel hazards or machinery damage, and any simulations to be used in the drill. The drill cards must give the correct procedure to be followed by each watch team member in the proper sequence for the drill. The purpose of the drill cards is to give the ECCET members ready reference to the proper procedures to be followed. The engineer officer must ensure that adequate research is done to ensure the accuracy of each scenario and pertinent drill cards. EOCC, if installed, should be the prime information source. The main propulsion assistant (MPA) should have custody of a master drill package, with appropriate copies of applicable drill scenarios and drill cards for each space.

The planning and scheduling of casualty control drills should receive equal priority with other training evolutions that are conducted during normal working hours. When a specified time for conducting casualty control drills is authorized by the commanding officer, the engineer officer must prepare a drill plan which provides for the training desired. Careful preplanning and sequencing of events is mandatory.

After the proposed drill plan is approved by the commanding officer, the designated ECCET personnel meet and make sure that each member of the team understands the procedures and the sequencing of events. In preparing the drill plan, consideration is given to the following:

1. General condition of the engineering plant.
2. Machinery and safety devices out of commission.
3. Length of time set aside for drills.
4. State of training of the watch section.
5. Power to be provided to vital circuits.

Within the constraints of the items listed above, first priority on drill selection is given to boiler casualty drills and propulsion space fire drills in that these drills represent the greatest danger and involve the largest number of propulsion plant watch team personnel. Second priority is given to lube oil system casualties because of the inherent danger to main and auxiliary equipments that these casualties represent. Third priority is given to other main engine casualties. In selecting drills, the engineer officer must give emphasis to the development of watch team proficiency in handling priority one type casualties.

Normally, ECCET members arrive on station shortly before the drills commence and ensure that communications are established throughout the plant. With the officer of the deck's (OOD's) permission, the drill initiator imposes a casualty in accordance with the drill plan. Within the boundaries of safety to personnel and equipment, drills are conducted as realistically as possible and simulations are kept to an absolute minimum. Any time a hazardous situation develops, ECCET members assist the watch section in restoring the plant to the proper operating parameters. Additionally, the ECCET members complete a drill critique form during the course of the drill.

As soon as possible following the drill, a critique is conducted. It is attended by personnel of the applicable watch section, the ECCET, and the engineer officer. The ECCET leader gives the finding for the drill and, in the case of unsatisfactory drills, provides the reasons for that finding. All other ECCET members then read their drill critique form. Drills are evaluated as satisfactory or unsatisfactory by the ECCET leader, based on a review of the critique sheets prior to the critique. The following deficiencies form a basis for a finding of unsatisfactory for a drill:

1. Loss of plant control by the EOOW or space supervisor when he is either unaware of the status of the plant, or unable to restore the plant to a normal operating condition utilizing EOSS/EOCC or other promulgated casualty control procedures.

2. Safety violations which cause a hazard to personnel or may result in serious machinery derangement.

3. Significant procedural deficiencies which indicate a lack of knowledge of the proper procedures to be followed in correcting a casualty.

CORRECTION AND PREVENTION OF CASUALTIES

The speed with which corrective action is applied to an engineering casualty is frequently of paramount importance. This is particularly true when dealing with casualties which affect propulsion power, steering, and electrical power generation and distribution. If casualties associated with these functions are allowed to spread, they may lead to serious damage to the engineering installation, a damage which often cannot be repaired without loss of the ship's operating availability. Where possible risk of permanent damage exists, the commanding officer has the responsibility for deciding whether or not to continue the operation of the equipment under casualty conditions. The operation of equipment under casualty control can be justified only where the risk of even greater damage, or loss of the ship, may be incurred by immediately securing the affected unit.

Whenever there is no probability of greater risk, the proper procedure is to secure the malfunctioning unit as quickly as possible even though considerable disturbance to the ship's operations may occur. Although speed in controlling a casualty is essential, action should never be undertaken without accurate information, otherwise the casualty may be mishandled, and irreparable damage and possible loss of the ship may result. War experience has shown that the cross-connecting of an intact system with a partly damaged one should be delayed until it is certain that such action will not jeopardize the intact system. Speed in the handling of casualties can be achieved only by a thorough knowledge of the equipment and associated systems, and by thorough and repeated training in the routine required to handle specific predictable casualties.

PHASES OF CASUALTY CONTROL

The handling of any casualty can usually be divided into three phases: (1) limitation of the effects of the damage, (2) emergency restoration, and (3) complete repair.

The first phase is concerned with the immediate control of the casualty so as to prevent further damage to the unit affected and to prevent the casualty from spreading.

The second phase consists of restoring, as far as practicable, the services which were interrupted as a result of the casualty. For many casualties, the completion of this phase eliminates all other operational handicaps, except for the temporary loss of the standby units-which lessens the ship's ability to withstand additional failures. If no damage to machinery occurred, this phase usually completes this phase of casualty control.

The third phase of casualty control consists of making repairs which completely restore an installation to its original condition.

SPLIT-PLANT OPERATION

In ships having two or more shafts, a fundamental principle of engineering casualty control is SPLIT-PLANT operation. The purpose of the split-plant design is to minimize damage that might result from any one hit.

Most naval ships built primarily as warships have at least two engineering plants. The larger combatant ships have four individual engineering plants.

Split-plant operation means separating the engines, pumps, and other machinery so that two or more engineering plants are available, each complete in itself. Each main engine installation is equipped with its own piping systems and other auxiliaries. Each engineering plant operates its own propeller shaft. If one engineering plant were to be put out of action by an explosion, shellfire, or flooding, the other plant could continue to drive the ship ahead, though at somewhat reduced speed.

Split-plant operation is not an absolute insurance against damage that might immobilize the entire engineering plant, but it does reduce the chances of such a casualty and it prevents damage to one plant from being transmitted to, or seriously affect the operation of, the other plant or plants. Split-plant operation is the first step in the PREVENTION of major engineering casualties.

The fuel oil system is generally so arranged that by means of fuel oil transfer pumps, suction can be taken from any fuel oil tank on the ship and the oil pumped to any other fuel oil tank. Fuel oil service pumps are used to supply oil from the service tanks to the main engines. In split-plant operations the forward fuel oil service pumps of a ship are lined up with the forward service tanks, and the after service pumps are lined up with the after service tanks. The cross-connection valves in the fuel oil transfer line are always closed except when oil is being transferred.

Although geared diesel propulsion plants are designed for split-plant operation only, some of the auxiliary and main systems maybe run cross-connected or split. Among these are the starting air systems, the cooling water systems, the firemain systems, and, in some plants, the fuel and lube oil systems.

In diesel-electric installations the diesel elements are designed for split operation, but generator elements can be run either split or cross-connected.

LOCKING MAIN SHAFT

An engineering casualty may affect the rotation of the main shaft and cause further damage. In such cases, the main shaft should be locked until necessary repairs can be made, since, except at very low speeds, movement of the ship through the water will cause the shaft to turn, whether the ship is proceeding by its own power or being towed.

There are no standard procedures for locking a main shaft which are applicable to all types of diesel-driven ships. On ships that have main reduction gears, shaft locking by means of the jacking gear is permissible, provided that the jacking gear has been designed for this purpose (as indicated, by the manufacturer's instructions) or when such action is approved by NAVSEA. Some ships are provided with brakes that are used for holding the shaft stationary. When no provisions have been made for locking the main shaft, it is usually possible to arrange a jury rig (preferably at a flanged coupling) which will hold the shaft. As a precautionary measure, jury rigs should be made in advance of an actual need for locking a shaft. On diesel-electric drive ships, no attempt should be made to hold the shaft stationary by energizing the electrical propulsion circuits.

EMERGENCY PROCEDURES

Under certain circumstances you may receive the order to light off additional engines. When time will not permit following normal routine procedures, emergency procedures may have to be used. Since procedures differ, depending on the installation, you must be familiar with the procedures established for your ship.

These emergency procedures are listed in the *Engineering Casualty Control Manual* for your ship. They are issued by the type commander. Upon receipt, manuals are modified to fit the individual installation. It is the responsibility of your ship's engineer officer to establish the step-by-step emergency procedures and the necessary checklists.

ENGINEROOM CASUALTIES

The type commander for each class ship formulates the engineering casualty procedures which are applicable to a specific type of engineering plant.

In the event of a casualty to a component of the propulsion plant, the principal objective is the prevention of additional or major casualties. Where practicable, the propulsion plant must be kept in operation by means of standby pumps, auxiliary machinery, and piping systems. The important action to be taken is to prevent minor casualties from becoming major casualties, even if it means suspending the operation of the propulsion plant. It is better to stop the main engines for a few minutes than to risk putting them completely out of commission.

When a casualty occurs, notify immediately the EOOW or the petty officer of the watch, who will in turn notify the OOD and the engineer officer. Main engine control must keep the bridge informed as to the nature of the casualty, the ship's ability to answer bells, the maximum speed available, and the probable duration of the casualty.

DIESEL ENGINE CASUALTIES

The Engineman's duties concerning engineering casualties and their control depend upon the type of ship-which may be anything from a PT boat to a carrier. An Engineman operates engines of various sizes, made by various manufacturers, and intended for different types of services.

Detailed information of diesel engine casualty control procedures must be obtained from the manufacturers' instructions, the pertinent type commander's instructions, and the ship's *Engineering Casualty Control Manual.*

Some examples of the types of engineering casualties that may occur, and the action to be taken are given below. The observance of all necessary safety precautions is essential in all casualty control procedures.

BROKEN INJECTION TIP

1. Cut out the faulty injector.
2. Notify the engineer officer and the bridge of the casualty. Request permission to secure the engine for repairs.
3. After permission has been obtained, secure the engine, remove the injector and replace it with the spare, following the procedures outlined in the appropriate maintenance manual.
4. After repairs are completed, test the engine. When it is operating properly, report to the engineer officer and the bridge.

BROKEN CYLINDER LINER

1. Secure the engine.
2. Report to the engineer officer and the bridge. Request permission to proceed with repairs.
3. When permission is granted, remove the head and piston; pull the broken liner and replace

it with the spare liner. Follow the procedure as outlined in the engine maintenance manual.

4. Make the necessary reports.

FAILED MAIN ENGINE LUBE OIL PRESSURE

1. Secure the engine immediately.

2. Notify the engineer officer and the bridge.

3. Check the sump oil level, the piping, the filters, the strainers, and the lube oil pump capacity. Make repairs.

4. After repairs have been completed, notify the engineer officer and the bridge.

WATER IN AN ENGINE CYLINDER, CRANKCASE, OR AIR PORTS

1. Notify the OOD and the engineer officer and keep them informed.

2. Do not allow the engine to be started until the cause of the casualty has been determined and corrected.

3. Check the cylinders by jacking over with test cocks open.

4. Put pressure test on freshwater system and conduct visual inspection of the units.

5. Replace part or parts, as necessary.

6. Start the lube oil purifier to remove water from the lubricating oil.

7. After repairs have been completed, test the engine and place it back in commission.

INOPERATIVE SPEED GOVERNOR

1. Control the engine manually, if possible.

2. Notify the engineer officer and the bridge, and request permission to secure the engine for repairs.

3. When permission has been obtained, check the governor control mechanism.

4. Check the linkage for binding or sticking.

5. Check the lubrication; flush and refill with proper oil.

6. Check setting of needle valve.

7. Make repairs. When they are completed, start the engine and check its operation. When it is operating properly, notify the engineer officer and the bridge.

LOST FUEL OIL PRESSURE

1. Notify the bridge.

2. Check the entire fuel system, including strainers, filters, and valves. Check the amount of fuel in service tanks, fuel lines, pumps, and relief valves until the trouble is found.

3. Make necessary repairs and test the engine.

4. Place the engine back in commission when the troubles are corrected.

ABNORMALLY HIGH LUBE OIL TEMPERATURE

1. Check the lube oil pressure.

2. Check the saltwater dump discharge pressure and the temperature of the cooling water.

3. Check the freshwater level in the expansion tank and the temperature of the freshwater.

4. Check the sea suction and the overboard valves.

5. Vent the freshwater and the saltwater pumps.

6. Check the operation of the thermostat control valve to the lube oil and freshwater heat exchanger.

7. Report any trouble found to the engineer officer and the bridge. Request permission to secure the engine for repairs.

8. When permission is received, make repairs.

9. After repairs are completed, check the engine and, after it is operating properly, report to the engineer officer and the bridge.

ENGINE COOLING WATER TEMPERATURE ABOVE THE ALLOWED LIMIT

1. Notify the bridge.

2. Reduce the load and the speed of the engine.

3. Check the freshwater level in the expansion tank.

4. Check the saltwater discharge pressure.

5. Check the sea suction and the discharge valves.

6. Vent the freshwater and the saltwater pumps.

7. Check the setting and operation of the temperature regulating valve.

8. If conditions warrant securing the engine at any time, secure and notify the bridge and the engineer officer.

9. Make repairs, test out the engine, and, if it is operating properly, notify the engineer officer and the bridge.

FUEL OIL CASUALTIES

In addition to casualties which may involve parts of the fuel oil system within the engine, other casualties may occur which involve the system outside of the engine. Examples of some of the possible casualties, along with the action to be taken follow:

WATER IN DIESEL FUEL OIL SERVICE (DAY) TANK

1. Shift fuel oil suction.
2. Notify the engineer officer and the bridge of the casualty.
3. Drain the water from all filters, strainers, and lines.
4. Open all test cocks on the engine, and turn the engine over until assured that the system is free of water.
5. Close the test cock. Start the engine. Check its operation. If operation is normal, notify the engineer officer and the bridge that the engine is ready for normal operation.
6. Strip or drain the contaminated service tank and refill with clean fuel using the fuel oil purifier.

INOPERATIVE DIESEL FUEL OIL TRANSFER PUMP

1. Line up the diesel purifier to supply the tank as quickly as possible.
2. Notify the engineer officer of the casualty.
3. In an emergency, line up and use the hand-operated pump in order to continue operation.
4. At the earliest possible time, inspect and repair the fuel oil transfer pump.
5. Report the results of the investigation and repairs to the engineer officer.

HYDRAULIC COUPLING CASUALTIES

Coupling casualties vary with each installation. The following examples, and the action to be taken, are applicable to some Fairbanks-Morse marine installations.

FAILURE OF THE MAIN LUBE OIL PUMP

1. Start the standby pump or the lube oil transfer pump and cut in on the line.
2. Cross-connect the twin hydraulic coupling systems.
3. Notify the engineer officer and the bridge of the casualty and the emergency measures taken.
4. At the earliest possible time, repair the hydraulic lube oil pump.
5. Report the repairs completed to the engineer officer and the bridge, and request permission of the engineer officer to start the pumps.

INOPERATIVE PROPELLER SHAFT PNEUMATIC BRAKE

1. Report the casualty to the bridge and the engineer officer.
2. Check the air pressure to the brake.
3. Check the air reducing valve to the brake.
4. Check the electrical and pressure control switches to the air control valve.
5. If the trouble is not determined and the use of the engine is required, do the following:

   a. Secure the air to the brake system until proper inspection of the brake shoes and expansion core can be made.
   b. Notify the bridge and the engineer officer that the engine is being operated without the brake, and that the throttle alone is being used for control.
   c. Use extreme caution during the operation.
   d. At the earliest possible time, inspect and repair the brake.
   e. Report the repairs to the engineer officer.

INOPERATIVE COUPLING LUBE OIL REGULATING VALVE

1. Maintain the correct operating pressure by manually operating the clutch dump valve.
2. Report to the engineer officer and the bridge. Request permission to secure the engine to effect repairs.

3. When permission is granted, replace or repair the valve.
4. Test for proper operation.
5. If the valve is operating properly, report to the engineer officer and the bridge.

OVERHEATING COUPLING

1. Check the system to determine the cause of overheating.
2. Regulate the valves manually to maintain proper operating temperatures.
3. Notify the engineer officer and the bridge. If it is necessary to secure the engine to effect repairs, request permission.
4. When permission is granted, secure the engine and effect repairs.
5. Upon completion of repairs, notify the engineer officer and the bridge.

COUPLING THROWING OIL

1. Check the system. Attempt to repair the leak.
2. Report to the engineer officer and the bridge. If the leak is not repaired, request permission to secure the engine for repairs.
3. When permission is granted, secure the engine, conduct an investigation, and make necessary repairs.
4. Upon completion of repairs, test the coupling.
5. Report to the engineer officer and the bridge.

HEAT EXCHANGER CASUALTIES

Following are the procedures to be followed under various conditions of operation when diesel engine heat exchanger casualties occur:

UNDER NORMAL STEAMING CONDITIONS

1. Notify the engineer officer and the OOD, and request permission to secure the engine.
2. When permission is granted, secure the engine.
3. Secure both the saltwater inlet and outlet valves to the heat exchanger.
4. Remove the visual inspection plate on the exchanger. Plug the expansion tank vent, and apply pressure to the freshwater side of the system by opening the valve from the ship's freshwater supply system, and check for leaks.
5. Upon detection of the leak, plug the tubes or install another core.
6. Upon completion of the repairs, notify the engineer officer.

DURING HOSTILITIES, WITH ACTION PROBABLE

1. Notify the engineer officer and the OOD, and request permission to slow the engine and increase speed on the other engine to maintain the speed required.
2. Reduce the saltwater cooling pressure to the heat exchanger by using manual control.
3. Keep a constant watch on the supply of freshwater in the expansion tank; keep the tank refilled from the ship's service freshwater system, to replace water lost through the leak. Observe all gages constantly for normal operating pressures and temperatures. Keep the engineer officer informed of operating conditions.
4. At the earliest possible time, make the necessary repairs.

OTHER PROPULSION PLANT CASUALTIES

Examples of other casualties which may affect propulsion plant operation are described below.

OVERHEATING MAIN SHAFT BEARINGS

Hot bearings may generally be traced to one of the following causes:

1. Insufficient lubrication.
2. Defective oil ring.
3. Grit or dirt in the oil.
4. Bearing out of line.
5. Bearing improperly fitted.
6. Poor condition of bearing or journal surface.

If the trouble is due to insufficient lubrication and is discovered before the bearing metal has wiped, an abundant supply of oil should gradually bring the bearing back to its normal operating temperature.

A defective oil ring should be repaired or replaced.

Should the trouble be caused by grit, dirt, or foreign matter in the bearing, the oil should be renewed. The new oil may flush out the impurities in the bearing surfaces sufficiently to permit continued operation.

If the main shaft bearing is out of line or improperly fitted, or if the bearing or journal is not in proper condition, only temporary relief can be obtained from use of the various means suggested above. The most effective treatment will probably be the operation of the main engines at low or moderate speeds until such time as the proper adjustments or repairs can be made.

Abnormal temperatures of a bearing can be lowered by slowing down the main shaft and thus decreasing the amount of friction in the bearing. If the trouble has reached an advanced stage, it may be necessary to stop the main shaft. In an emergency, cold water may be used on a bearing to reduce the temperature so that it will be within safe operating limits; it must be remembered, however, that cold water will cause contraction of the bearing. Also, care must be taken to see that water does not contaminate the bearing oil.

Once a bearing has wiped, it should be reconditioned. If it has wiped out slightly, it can probably be scraped to a good bearing surface and restored to service. If badly wiped or burned out, the bearing will require replacement. Inspect the journal and remove any high spots by lapping the journal.

UNUSUAL NOISE IN REDUCTION GEAR

This information applies to diesel-driven ships that have main reduction gears. The action taken will depend upon the two following conditions:

1. When noise and conditions indicate that tooth failure is not probable:

   a. Slow the engine immediately and stop it if the noise persists.

   b. Check the oil discharge pressure, the temperature of the bearing, and the operation of oil sprays and strainers. Look for the presence of babbitt or other foreign matter.

2. When there is a loud or roaring noise indicating gear tooth damage:

   a. Stop the engine and check the shaft immediately.

   b. Lock the main shaft in accordance with EOSS/EOCC procedures or the manufacturer's instruction.

   c. Make a preliminary investigation of the gear teeth and other parts of the main reduction gear.

PROPULSION SHAFT VIBRATES EXCESSIVELY

When the propulsion shaft vibrates excessively, take the following actions:

1. Slow the shaft. If the vibration continues, stop and lock the shaft.
2. Investigate to determine the cause of the vibration. Take necessary action to correct the cause of the vibration.

Frequently, the circumstances under which a ship is operating should be considered when trying to determine the probable cause for excessive vibration. For example, if the ship is in shallow water or close to a beach, the vibration may be caused by the propeller striking ground.

ELECTRICAL CASUALTY CONTROL

Since Enginemen and Electrician's Mates are assigned duties in operating diesel-driven emergency generating plants on steam-driven ships, and all electrical generating plants on diesel-driven ships, they must have a general knowledge of the purpose of electric generating plants, their operation under various conditions, and the types of casualties that will interfere with, or disrupt, the normal operation of an engineering plant.

THE ELECTRICAL PLANT

The ship's power and lighting plant consists of generators, switchboards, power panels, cables, circuit breakers, and other equipment necessary for the generation, distribution, and control of power supplies to electrically driven auxiliaries, lighting, interior communication, electronics equipment, and other electrically powered devices. In designing the electric plant, every effort is made to obtain the greatest reliability and continuity of service possible under casualty conditions.

The distribution system forms the vital connection between the generators and the equipment which uses electric power. The distribution of electrical power is generally done through either the ship's service or the emergency switchboards. Electrical power distribution may also be done through a casualty power circuit rigged from either of these switchboards.

The general arrangement of the ship's service system is such that any faulty circuit will be cut out automatically, without interruption of power supply to other circuits. This is done through the operation of protective devices. If the ship's service generators fail, the emergency generator is automatically placed in operation for battle functions. The emergency switchboard can supply power to all parts of the ship; however, all unnecessary circuits must be stripped from the board when the emergency generator is set up in automatic to supply emergency power to vital equipment. If this is not done, the generator will be overloaded and the breakers will trip out or the diesel engine will stall.

Protection against loss of power on a ship with ship's service, emergency, and casualty power distribution systems is described below:

1. FAILURE OF ONE SHIP'S SERVICE GENERATING PLANT. The load is transferred, by the Electrician's Mate, to the other ship's service generating plant. Care must be taken to prevent overloading the generating plant that takes over the load.

2. CIRCUIT OR SWITCHBOARD FAILURE. Vital loads are transferred to an alternate feeder and source of ship's service power by means of a transfer switch on the control panel.

3. FAILURE OF BOTH NORMAL AND ALTERNATE POWER SUPPLY. Certain vital equipment are shifted to an emergency feeder which receives power from the emergency switchboard.

4. FAILURE OF THE SHIP'S SERVICE AND EMERGENCY CIRCUITS. Temporary circuits are rigged with the casualty power cables from any live switchboard to supply power to vital circuits.

EMERGENCY POWER SYSTEM

The purpose of the emergency power system is to furnish an immediate, automatic source of electric power to a limited number of selected vital circuits. It includes one or more diesel-driven emergency generators, the emergency switchboards, and a distribution system, which is separate from the ship's service electric plant and distribution system. Emergency feeders run from the emergency switchboards to at least one and usually to two different ship's service switchboards. Emergency power feeders for certain vital auxiliaries are also run to control panels. The emergency power system, with the use of transformers, is also used for furnishing emergency lighting.

Whenever practical, emergency generators and switchboards are installed above the waterline, to minimize danger from flooding. Also, the emergency plant is installed as far away as practical from the ship's service plant, to avoid both plants being put out of action by battle damage.

On most ships, the emergency generators do not have the same capacity as the ship's service plants. Therefore, care must be taken to prevent overloading the emergency generator, which in turn will overload the diesel engine.

CASUALTY POWER SYSTEM

The casualty power system is used to supply emergency power for steering gear, fireroom and engineroom auxiliaries, fire pumps, drainage pumps, communications equipment, and other vital machinery needed to keep the ship afloat or to get it out of a danger area.

The casualty power system is a simple electrical distribution system used to maintain a source of electrical supply for the most vital machinery and equipment needed to keep the ship afloat and functioning. This casualty power system is intended to supply power during emergencies ONLY. The system is purposely kept simple so that it can be rigged quickly and with a minimum chance of error; but, the very simplicity of its design limits the extent of its use.

Sources of supply for casualty power use are provided at each ship's service switchboard and at each emergency switchboard. They consist of casualty power terminals that are connected to the bus bars through circuit breakers. Some ships have small diesel-driven generators which are designed for casualty power use only; these generators are very small and have a minimum of control equipment. Casualty power terminals are installed on power panels that feed equipment designated to receive casualty power; these terminals may also be used as a source of supply to the casualty power system if power from the permanent feeders to the panels is still available.

The casualty power system is either a.c. or d.c., as appropriate for the particular installation. Only the a.c. system is described here. The d.c. system is similar to the a.c. system, but uses different types of cables and fittings.

The portable, thermoplastic-covered or neoprene-covered cables for the a.c. casualty power system are stowed in racks in convenient locations throughout the ship. Each cable contains three leads (conductors), colored black, white, and red. This same color code is used in all three-wire power circuits throughout the ship.

On smaller ships, the bulkhead terminals for the casualty power system are arranged so as to allow for one horizontal run of the portable cable along the main deck, and generally, if possible, inside the deck house. On larger ships, generally there are terminals for two horizontal runs of cable, one port and one starboard. These are located on the second deck. The terminals extend through the bulkhead and project from it on each side, and do not impair the water-tight integrity of the compartments in which they are installed. The cable ends are inserted into the holes that are provided around the outer rim (curved surface) of the terminal. Both the rim and the face of each terminal have three groups of three holes each, into which fit the square-shanked, insulated wrenches that are used to secure the cables in the terminal. Two square-shanked wrenches are provided in the rack mounted on the bulkhead at each point where they will be required. These wrenches MUST be kept in the racks at all times when they are not actually in use.

The riser terminals for the casualty power system are similar to the bulkhead terminals, except that they are connected to other riser terminals by vertical runs of permanently installed, armored cable. The risers and the riser terminals carry the casualty power from the level of the generators to the main deck and second deck levels.

Portable switches are sometimes provided on the bulkheads, near the cable racks. These are simple ON-OFF switches which have special holes for use with the portable cables.

The terminals and the cables in an a.c. casualty power system are marked so that they can be identified easily when the system is being connected. The faces of the terminals are marked A, B, and C, and the three leads on each cable are colored black, white, and red, respectively. When connecting the cables to the terminals, you connect the black lead to A, the white lead to B, and the red lead to C. Since the letters and the colors cannot be seen in darkness, the terminals are further identified by molded knobs in the A, B, and C areas—one knob for A, two for B, and three for C. The cable leads are identified by servings of twine—one for black, two for white, and three for red. Each serving of twine is about 1 inch wide. Thus each lead and its corresponding position in the terminal can be identified merely by feeling the leads and matching the number of pieces of twine on each lead with the number of raised knobs on the terminal. (In older ships, the casualty power fittings may still have identifying V-shaped notches in the outer edge instead of raised knobs.)

CAUTION: When connecting a run of casualty power cable, ALWAYS CONNECT FROM THE LOAD BACK TO THE POWER SUPPLY! By rigging the system in this manner, you will avoid working with an energized cable. Also be SURE to shut off the normal supply to any power panel before you connect the casualty power cable to the terminals on the power panel.

EMERGENCY FIRE PUMPS

Most ships have electric-driven fire pumps located outside the engineering spaces. These pumps furnish water under presssure to their own piping system or to the ship's firemain. Provisions are made for different sources of electrical power to these pumps: normal and alternate supply from the ship's service generators, emergency supply from the diesel-driven emergency generators, and the casualty power system itself.

Many ships, such as carriers, tankers, and tugs, have independent diesel-driven fire pumps. If ship's pumps and firemain are damaged, these diesel-driven pumps can be used to furnish large amounts of water for firefighting purposes.

LIGHTING SYSTEM

On ships using a.c. generators, the ship's service and emergency lighting systems are energized from the generator and distribution switchboards through a bank of transformers. These transformers supply power to the lighting system through the lighting distribution panels.

Lighting throughout the machinery spaces is supplied from the normal switchboard for the compartments involved, with some lights in each space supplied from the alternate switchboard. A few lights in each compartment are supplied through automatic bus transfer equipment from circuits originating at the emergency switchboards. A few lights in each compartment are supplied through automatic bus transfer equipment from circuits originating at the emergency switchboards.

Automatic type hand lanterns are provided to supply an instantaneous source of illumination, in the event of complete failure of the ship's service and emergency lighting systems. These relay-operated hand lanterns are installed at vital stations. In addition to these, nonautomatic type hand lanterns are also installed at these stations.

An EN1 or ENC in charge of an engineering space has the supervisory responsibility to see that the hand lanterns, especially the automatic type, are not removed except for actual intended use, and that hand lanterns are available for use at all times. Although the Electrician's Mates have the responsibility for the maintenance of the hand battle lanterns, it is the duty of the petty officer in charge of the space to see that personnel do not remove the lanterns or use them for unauthorized purposes.

The EN1 or ENC should also ensure that personnel have an adequate number or flashlights available for use should all the lights in an engineering space go out.

ELECTRICAL POWER PANELS AND TERMINALS

Power panels are supplied with two or three sources of power—normal, alternate, and emergency. These panels are equipped with circuit breakers or switches which permit the transfer from one source to another in the event of a casualty.

Regular electrical outlets are installed throughout the engineering spaces for use with small portable tools; multipurpose outlets are installed in selected locations for use with portable submersible pumps and portable welding sets. These outlets are located so that it is possible to use two portable submersible pumps in any watertight compartment. Portable triple outlet extension cables are provided to permit the concentration of all submersible pumps in one area. An adapter provided with these extension cables permits connection of the submersible pumps to the casualty power terminals. All this equipment is stowed in the damage control lockers.

Engineroom personnel should be trained in the emergency use and operation of submersible pumps as well as other damage control equipment. They should know the location of both normal and emergency power outlets in their spaces, and should understand the different methods used to supply electrical power for operating submersible pumps in the engineroom.

Engineroom personnel should also be familiar with sources of electrical power provided to the different power panels in an engineroom. During engineering casualty control drills and during actual emergencies, the Enginemen should be able to shift from one source of electrical supply to another.

BATTLE CASUALTIES

As an EN1 or ENC you will be responsible for handling battle casualties, you will have to know the location of isolating and cross-connecting valves, and recognize which of the valves are remotely controlled. As a general rule, personnel safety will be your first consideration in handling casualties.

Effective control of battle casualties depends on a good knowledge of the principal engineering piping systems and related equipment. This information may be found in the ship's *Engineering Casualty Control Manual*, in the *Damage Control* Book, in the plans of the principle engineering systems, and in other applicable sources located aboard ship.

In the event of a battle casualty to an engineering piping system, the damaged section must be isolated and the system should be cross-connected, when possible. Emergency or alternate equipment should be used, when provided, to restore service to vital systems. Whenever feasible, emergency repairs should be made and the system restored to normal operation. Special precautions should be taken to prevent additional damage which may result from any original casualty.